Nanofluid/Ultrasonic Atomization Minimal Quantity Lubrication System

1. **Merchandise Name :** Nanofluid/Ultrasonic Atomization Minimal Quantity Lubrication System

2. **Developing Staff Members**

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3. **Development Idea**

With the advancement of science and technology, products are becoming more refined and miniaturized, and fine manufacturing has become the future trend. Micro Mechanical Machining has been widely used in industries such as electronics, communications, biomedicine, aerospace engineering, and the automotive industry. However, there are still many bottlenecks in micro-machining, such as poor surface quality and unstable tool life in micro-machining. Although cutting fluid can be added to cool and lubricate the processing area to improve the quality of micromachining, cutting fluid has caused harm to the environment and human health as follows :（1）If the waste fluid of cutting fluid is not handled properly, water resources will be seriously polluted.（2）The biodegradability of the waste liquid is poor. Even after repeated strict treatments, if it stays in the water and soil for a long time, the continuous accumulation will cause environmental pollution.（3）The toxic chemical components remaining on the chips can also pollute the air.（4）The pungent odor generated and emitted when using traditional cutting fluids will cause harm to the operator's respiratory system. Long-term exposure to the added chemicals can cause cancer, so people who have long-term exposure to bad cutting fluids are prone to respiratory diseases. To solve the above-mentioned environmental hazards, a new lubrication method, Minimum Quantity Lubrication（MQL）, is developed, which uses high-pressure air to spray a tiny amount of cutting fluid to the machined surface through a nozzle, which has not only the effect of lubrication and cooling but also Environmental pollution and personnel health problems can also be improved. This technology uses Nanofluid in a self-developed and designed ultrasonic atomization micro-lubrication system（Ultrasonic Atomization MQL, 2 invention patents have been taken）. Nanofluid is composed of nanoparticles with an average particle size of less than 100nm added to the base fluid. Nanofluid has excellent thermophysical properties and can effectively reduce the heat generated during micromachining. However, the characteristics of nano-particles can cause Vander Waals between the nanoparticles, which leads to agglomeration of the nano-particles, which

reduces the efficiency of the use of nano-fluids. To solve the problem of agglomeration, an ultrasonic wave is designed. The decentralized technology combined with the micro-lubrication system is different from the micro-lubrication system. A small amount of cutting fluid is atomized by high-pressure air and then sent to the cutting area. The ultrasonic atomized micro-lubrication system designed by this technology uses high-frequency vibration to divide the nanofluid into very tiny oil droplets and then uses high-pressure air to send out through the nozzle so that the smaller oil droplets can enter the cutting area more easily. Better cooling and lubrication effect. This method can also greatly reduce the energy consumption caused by the recycling of cutting fluid and the long-term operation of the cutting fluid pump of the micro-machine tool machine. In practical applications, this technology also proposes to use a variety of intelligent modeling methods for design and development, which can simultaneously discuss and optimize the actual goals of multiple micromachinings and different manufacturing processes. This technology has a complete theoretical method, and has practical application value in the industry, and can contribute to smart manufacturing and green manufacturing technology in related industries.

4. Technological Competition and Industrial Application

This technology is the first in the world. There is no particular equipment system for dispersing and atomizing nanofluid micro-lubrication in the world. Minimal Quantity Lubrication (MQL) refers to the use of high-pressure air to atomize and mix a minimal amount of cutting fluid (below 50hr/ml) and spray it to the cutting position through a nozzle to achieve the effect of lubricating and cooling. It has been an emerging processing lubrication technology in recent years. The primary purpose is to reduce the use of a large amount of cutting fluid and the cost of fluid waste treatment, and to reduce the harm to the environment and engineering personnel, to meet the current environmental awareness and regulations. Taking Germany and Japan, which are leading in manufacturing technology and scale in the world, for example, the related cost of cutting fluid in their manufacturing industry accounts for about 20% of the overall part processing cost. The annual amount of cutting fluid is as high as 800 million liters. The energy consumed accounts for about 10% of the total energy consumption of the entire plant. Therefore, reducing the use of cutting fluid is an inevitable trend in today's industry. This technology's ultrasonic atomization system differs from the general micro-lubrication technology that uses high-pressure air atomization. Stage atomization so that the liquid nanofluid is converted into a gaseous state and can more easily enter the cutting area for cooling and lubrication. Ultrasound is a sparse and dense wave, so it has diastolic and compressed parts. When the compact part

is in, the pressure in the liquid is positive; in the diastolic function, the pressure in the fluid is negative. When the negative pressure amplitude is large enough and the period is long enough, cavitation bubbles will be generated. When the wave reaches the diastolic part, the bubble will be unstable, and its size will expand rapidly. When the diastolic function is transmitted to the compression part, the pressure of the surrounding liquid rises, and the bubble begins to collapse. As the pressure continues to increase, the speed of collapse also increases. Intensify, burst, or implode instantaneously in the liquid to produce a potent impact, resulting in the so-called cavitation. This system is self-developed and produced.

A DC voltage is applied to the piezoelectric ceramic sheet (PZT) . The piezoelectric ceramic sheet with the inverse piezoelectric effect generates high-frequency vibration in the thickness direction to transfer the vibration energy to the nanofluid and then uses the ultrasonic cavitation principle. And characteristics, high-intensity shock waves are generated on the liquid surface of the nanofluid to atomize the nanofluid into tiny particles. The fluid is atomized in the atomization chamber. Then the atomized particles are taken out of the atomization chamber through low-pressure air, and the particles are transported to the nozzle end through a conduit Area. This technology and design use various intelligent modeling methods to explore the impact of processing methods on various processes. The relevant results of the research have been published in many international high-quality journals, such as IEEE Transactions, and have also been recognized by the 2021 FutureTech Award.

5. Merchandise Statement of Achievement

The technical team has been committed to the research, development, and application of green manufacturing technology for a long time. The technical level of the manufacturing industry is an essential manifestation of a country's comprehensive national strength. However, in the manufacturing process of industrial products, the waste gas, waste liquid, waste, and a large amount of energy consumed by production equipment have caused severe environmental pollution, resulting in an ecological crisis characterized by resource depletion and environmental degradation. For example, a large amount of cutting fluid is usually used in the traditional cutting process. Although cutting fluid plays a vital role in cooling, lubrication, and auxiliary chip removal, it dramatically impacts resource consumption, the environment, and human health. The negative effect and the use cost of cutting fluid also account for a large proportion of the overall processing cost. Therefore, it is necessary to develop green manufacturing technology in the manufacturing process. Green cutting technology is an integral part of green manufacturing. This technology means that it has no toxic or side effects on the ecological environment and the small environment of the processing

site and produces a small amount of waste gas, waste liquid, and waste during the processing process to meet the environmental protection requirements of pollution-free, is a processing technology that does not harm human health and the environment. In recent years, green manufacturing technology has become an international research hotspot, and all countries have invested a lot of resources to develop this technology.

To further enhance the benefits of evolutionary MQL, the research team developed a series of nanofluidic MQL devices. It can effectively solve the problem of particle accumulation caused by the long-term processing of nanofluids and, at the same time, improve the efficiency of nanofluids in use. The related equipment developed and designed has also obtained several invention patents. A series of correlation studies have been carried out in this technology, including adding different nanoparticles into different base fluids to prepare nanofluids with different weight percentage concentrations and using various intelligent modeling methods to discuss the various the influence of other processes (micro-milling, micro-deep hole drilling, super-hard alloy grinding after heat treatment) . This technology is subsidized by the Ministry of Science and Technology's industry-academia cooperation program cooperation and academic research programs. It takes " Nanofluid/Ultrasonic Atomization MQL System " as the subject of industry-academia cooperation practice and educational method research. A series of technologies and processes can significantly reduce time and cost. After years of R&D improvement and practical verification through the cooperation plan with many partners, it can significantly increase the demand and efficiency in green manufacturing technology micromachining. The developed technology has practical applications and can contribute to related industrial process technology and green manufacturing technology. The research and development results have substantial benefits for the industry in reducing environmental pollution in terms of green technology, recycling a large amount of cutting waste fluid, and energy consumption. The energy consumption of cutting fluid pumps in machine tools is significantly reduced. It dramatically impacts the technological development and improvement of industrial smart manufacturing and green manufacturing technology. Substantial contribution.

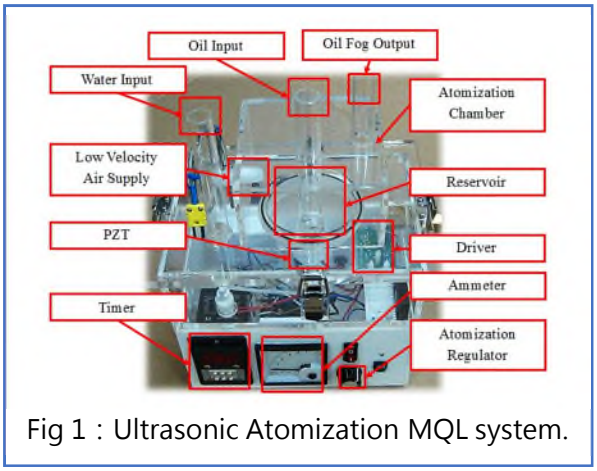

Fig 1：Ultrasonic Atomization MQL system.